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The Economics of Integrating Injury and Illness Prevention and Health Promotion Programs

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Abstract

There is a growing interest in coordinating employer programs to promote health and reduce occupational injuries and illnesses. While efforts to study the effectiveness of both types of programs separately are methodologically challenging, most studies suggest that health promotion and injury and illness prevention activities can reduce the frequency and severity of negative health outcomes for workers. There is little evidence, however, on whether or not the effectiveness of interventions are enhanced by combining the two types of programs into a single all-encompassing effort by employers to improve worker health. This paper uses an economic model to explore whether or not a coordinated effort by employers would lead to superior health outcomes for workers. The model suggests that improved outcomes can result if there are "spillovers" from nonoccupational and occupational risk factors. In other words, if factors that influence individual health at home and work combine to influence health in a synergistic fashion, then there will be a gain to coordinating health promotion and injury prevention programs. Using data from the Health and Retirement Survey (HRS), we search for evidence of health spillovers for two important risk factors that are generally thought to jointly contribute to negative health consequences: smoking and exposure to harmful substances at work (e.g., asbestos). We confirm past evidence that these two factors do combine to worsen health outcomes beyond what would occur if individuals were exposed to either in isolation, but the evidence also suggests that other, unobserved factors likely contribute to the estimated spillovers.

1. Introduction

Rising health care costs in recent years have intensified the interest of employers in promoting a healthy workforce. Data from the Bureau of Labor Statistics (BLS) show that in 2001, employer-provided health insurance, short and long-term disability programs, and workers' compensation at private industries in the United States combined to total almost $294 billion.[1] These costs have led employers to take steps to attempt to reduce adverse health outcomes both in and out of the workplace. Programs to reduce the onset of illnesses and injuries at work are generally referred to as *injury and illness prevention* programs, while programs targeting nonoccupational health conditions are known as *health promotion* programs. While a substantial amount of research has focused on evaluating the effectiveness of these programs in isolation, there has been too little attention given to the potential benefits from coordinating these programs.

Traditionally, there has been only modest overlap between research in the areas of occupational and nonoccupational health. The strong distinction between the two has been driven at least partly by their differing compensation mechanisms; individuals with occupational health conditions are usually eligible for workers' compensation benefits, whereas those with nonoccupational conditions are not. Workers' compensation is mandated in almost every state, and provides income as well as medical benefits. Employers have covered health care and compensation for lost income for nonoccupational conditions optionally, without integration with workers' compensation. In practice, the distinction has been so strong that it has even helped spawn the subcategory of medicine referred to as occupational medicine.

Despite the historical reluctance to consider the two issues jointly, the changing nature of work and the workplace environment in the U.S. has begun to erode the justifications for keeping them separate. Over time, the prevalence of acute traumatic workplace injuries, most notably workplace fatalities, has fallen (Loomis, Bena and Bailer, 2003), leading to an increased focus on work-related chronic conditions, such as low back pain. It is considerably more difficult to determine the workplace causality of chronic conditions, which has helped to blur the distinction between occupational and nonoccupational injuries. In addition, the increasing use of off-site

[1] This figure is based on the authors' calculations using data from the US Department of Labor, Bureau of Labor Statistics (BLS), Employer Costs for Employee Compensation. See www.bls.gov for more information. The BLS reports these individual cost components as hourly rates. We estimated the total cost by computing the total hourly cost, and then multiplying by the total number of work-hours (assuming individuals work 50 weeks a year).

contractors and telecommuting also complicates the ability to pinpoint the work-relatedness of any given health condition (Smith, 2003).

As the distinction between occupational and nonoccupational health fades, it becomes natural to think about the impact of workplace and employer interventions on *all* health conditions, and to think about the impact on employer costs for all mandated or employer-sponsored health programs. In particular, it raises the question of whether or not the integration of injury and illness prevention and health promotion programs will lead to improved outcomes for workers and employers. In this paper we analyze the relationship between health promotion and injury prevention using an economic framework. In particular, we discuss the concept of synergies, or "spillovers," between efforts to reduce health risks for both occupational and nonoccupational conditions.

Our paper also discusses how the relationship between occupational and nonoccupational health risks, and the impact of efforts to curb them, could be measured empirically. We use the Health and Retirement Study (HRS) to provide a simple example of some evidence on the relationships between occupational and nonoccupational health risks. We focus in particular on the combined impact of smoking and exposure to harmful chemicals or substances at the workplace on the onset of an adverse health condition. This analysis allows us to document the extent to which we observe health-related spillovers for two important public health concerns that are generally thought to contribute to each other's negative health consequences.

We proceed as follows. In the next section we discuss past work on the impact of injury and illness prevention and health promotion programs. In Section Three we model the conceptual relationship between health promotion and injury prevention programs. Our discussion draws distinctions between the potential individual and combined impacts of interventions targeting health "inputs" (i.e., risk factors) on health outcomes (e.g., the onset of disease or disability), as well as the potential impact on program costs. The fourth section describes our empirical analysis. Finally, we conclude with a discussion of the implications of our paper for future research on injury and illness prevention and health promotion.

2. What do we Know About Injury and Illness Prevention and Health Promotion Programs?

In this section we briefly review the empirical literature on the effectiveness of health promotion and injury prevention activities. If these programs are not able to improve health outcomes in isolation, it is doubtful that there will be any substantial gains to coordination. There has been a substantial amount of work dedicated to both areas, with several thorough reviews of the literature. Rather than duplicate this work, we simply highlight some of the broad themes, and direct the interested reader to these reviews for further study.

Health promotion programs usually target personal health habits, or activities taken by individuals that impact their health. Aldana (2001) categorizes the major health risks that have been studied in the literature into ten primary categories: tobacco use, body mass index (BMI) and obesity, cholesterol, hypertension, stress, diet, alcohol abuse, seat belt use, fitness or physical activity and multiple risk factors.[2] These are similar to the set of risks studied in Anderson et al. (2000), who found that modifiable risks accounted for 25% of total expenditures for health care (although what they find is the most costly factor, stress, is not considered in the studies reviewed by Aldana). Some of these risks are direct measures of health habits, while others are probably best thought of as proxies for the actual habits of interest. For example, tobacco use is a direct measure of smoking behavior, but obesity is probably better thought of as a measure of some combination of caloric intake and physical activity (and in some cases genetics).

Health promotion programs attempt to induce workers to modify these behaviors to reduce the onset of negative health consequences. There are many interventions that might be part in a health promotion program. Employers might try to educate workers on the dangers of smoking. They might remove vending machines in an effort to improve workers' nutritional habits. Regardless of the type of intervention used in a health promotion program, ultimately the decision is up to workers; employers can typically only influence health habits by altering workers' incentives.

In contrast, most injury prevention programs involve a more direct intervention by employers. Instead of convincing workers to modify risky behavior, employers usually modify

[2] Aldana does not specifically include studies about tobacco use in his review, though he does acknowledge it as an important risk factor.

the workplace environment to directly reduce the risk of injury. Zwerling et al. (1997) describe four major categories of interventions: engineering, administrative, personal and multiple interventions. Engineering interventions represent changes to the physical environment in which individuals work in an attempt to reduce the risk of negative health outcomes. Administrative interventions involve modifications to employer-mandated policies or procedures that may have an impact on workplace safety. Personal interventions attempt to reduce adverse health outcomes for workers with education and training, and are the most similar to health promotion activities. The final category, multiple interventions, deals with programs that try any combination of these approaches.

The scientific literature on health promotion and injury and illness prevention programs typically attempts to measure the effectiveness of programs by measuring their impact on some health outcome, such as the onset of a particular disease or injury, or some cost measure, such as medical care expenditures. These latter measures are important because they speak to the cost-effectiveness of the programs, i.e., the extent to which the value of outcomes from the program exceeds the cost implementing it. Given that employers bear the cost of these programs, this raises an interesting question; what are the benefits to employers of investing in worker health?

One explanation for the prevalence of employer efforts to promote health could be that employers are altruistic, and care about the well being of their workers. Another is that they are required to do so, through government regulations such as the Occupational Safety and Health Act (OSHA). Additionally, there is a more traditional economic argument suggesting that some positive level of investment in worker health is profit maximizing for employers. The impact of occupational injuries and illnesses for employer costs is fairly straightforward, as employers are liable for medical and indemnity costs through workers' compensation. Leigh et al. (1997) estimate an annual direct cost to employers of approximately $65 billion for occupational injuries and illnesses. With regard to nonoccupational health conditions, the most obvious explanation for the prevalence of health promotion programs is the widespread existence of employer-provided health insurance. Rising medical costs for workers contribute substantially to employer costs, raising the incentives of employers to encourage preventative measures by workers.[3]

[3] An important question here is whether these costs are ultimately passed on to workers, in the form of lower wages. For example, Krueger and Burton (1990) and Gruber and Krueger (1991) find that costs from workers

In addition to the direct financial incentives from higher labor costs, poor health could also have a negative effect on the productivity of workers. For example, Stewart et al. (2003) estimated that common pain conditions were responsible for reduced performance costing employers $61.2 billion per year. Likewise, Berger et al. (2003) estimate that 5 to 10 percent of the "effective" workforce is lost because of health problems. If poor health makes workers less productive, and if employers are unable to replace unhealthy workers with healthy ones at no cost (or unhealthy trained workers with healthy untrained workers), then employers will also obtain some benefit from reducing poor health among workers. In an attempt to account for these indirect benefits, some studies of health promotion programs also evaluate the impact on employee absenteeism (Aldana, 2001). Nevertheless, evaluations of health interventions by employers rarely measure such costs as retraining and search costs.

In general, the literature tends to find that both injury prevention and health promotion programs are able to reduce health risks and improve outcomes for individuals. The four studies cited by Aldana (2001) that use randomized study designs, Fries et al. (1993), Leigh et al. (1998), Fries et al. (1994) and Bly et al. (1986), all use report significant decreases in the utilization of health care for those treated with health promotion interventions. All but Bly et al. (1986) report a reduction in medical costs among the treated group. Many studies using nonexperimental or quasiexperimental designs also report significant reduction in health expenditures. However, most studies place little emphasis on the actual cost effectiveness of the programs. The studies are limited both in the measures of cost, and in the measures of benefits to employers and even to workers. Additionally, the literature suffers from too little focus on the representativeness of the study populations being considered and the long-term impact on outcomes for employers and workers (Bull et al., 2003).

Similar results, and problems, exist for the literature on injury prevention programs. Zwerling et al. (1997) list a number of studies that report improved injury and illness outcomes resulting from different forms of interventions. However, the overall literature on injury prevention appears rather limited, with relatively few scientifically designed studies (c.f., Dannenberg and Fowler, 1998; Hulshof et al., 1999). Thus, while work does exist documenting

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compensation are mostly offset by lower wages. If these costs are perfectly passed on to workers, it should reduce the financial incentives for health promotion and injury prevention activities by employers.

positive effects of injury prevention programs, far more work is needed to establish the cost effectiveness of such programs.

Given some of the difficulties in establishing the effectiveness of health promotion and injury prevention programs in isolation, it is perhaps unsurprising that there exists little work considering the two together. Economists have begun to consider the question of how both occupational and nonoccupational factors combine to influence health more broadly, however. In the remainder of this paper, we discuss how the application of theoretical and empirical economic tools can contribute to our understanding of the cost effectiveness of health promotion and injury prevention activities.

3. A Model of Occupational and Nonoccupational Injury and Illness Prevention

In this section, we describe an economic model of how health promotion and injury prevention may jointly affect health. This allows us to formalize the conditions under which the coordination of health promotion and injury and illness prevention programs will improve outcomes for employers and workers. The technical details of the model and the derivation of the results are presented in the appendix, and here we simply describe the analysis and provide the intuition behind the results.

As is the case with any model, it is necessary to simplify our analysis and consider only a few broad concepts. With respect to outcomes, we focus our discussion on health shocks to individuals. In occupational terms, these could be the onset of a workplace injury or illness, which could be fatal or nonfatal.[4] A nonoccupational health shock could represent a fatal injury or illness, or the onset of some morbidity or work disability. For our purposes, the only relevant distinction between occupational and nonoccupational is in describing the risk factors, not in describing the actual health outcomes.

In terms of inputs to individual health, we simplify the analysis by separating nonoccupational inputs by individuals from occupational inputs by employers. In other words, we assume that individuals can only directly affect their own health through their actions away from work, while employers only directly affect worker health through the workplace environment. This is clearly an abstraction; as we stated earlier, it is becoming increasingly

[4] While a chronic condition might take years to develop, we can think of the "health shock" as being the point at which the condition becomes potentially disabling.

difficult to distinguish individual behavior at and away from work. Nevertheless, this formulation allows us to consider how both home and workplace conditions combine to influence individual health.

The standard economic model for studying how health evolves over an individual's life is due to Grossman (1972), and it formulates health as an investment good. Two recent economic applications have adapted the health investment model to incorporate the relationship between health and work. Case and Deaton (2003) studied how "backbreaking" work in low-income jobs impacts the rate of health depreciation over time. Lakdawalla and Philipson (2004) focus on how the level of physical activity at work affects one important aspect of health: weight. While both of these studies, and the Grossman model in general, emphasize a "smooth" lifetime model of health, our focus is different. We focus on how individual health habits and the work environment combine to affect what are essentially discrete shocks to health, in the form of the onset of a disabling injury or illness. For simplicity, we ignore direct investment in the *level* of health by individuals and focus only on individual and employer efforts to prevent or limit negative health shocks. In this specification, both individuals and employers can influence the likelihood of adverse health shocks, but neither is able to rule them out completely.

Perhaps the most important part of the model is specifying how individuals and employers choose to make decisions about the level of investment in health. First consider the case of individuals. Following standard economic practice, we assume that individuals are motivated to maximize a "utility function" that is increasing in both consumption of goods and health subject to a budget constraint. Thus, individuals are limited in the amount they can "spend" on investments in health.[5] Economic theory predicts that individuals will balance investment in their health with the cost in terms of consumption of other goods, based on how they perceive the value of each. As long as future health and utility are unambiguously increasing in current period investments to stave off future health shocks, economic theory holds that individuals will invest in their health until the expected marginal value of the increase in future utility equals its cost. In other words, individuals invest in protecting themselves until the gain in higher expected health is outweighed by the cost of more investment.

[5] For modeling purposes we represent the costs of individual investment with a fixed monetary price, though our results would be unchanged if we incorporated a more realistic specification in which the price of investment took the form of time or effort.

Now consider the decision of employers to invest in worker health. Again following standard economic practice, we assumed that employers are motivated to maximize profits for shareholders. This ignores other potential explanations for the existence of health promotion programs, such as employer altruism. In this sense, it is important to emphasize that we are searching for justifications of integrated health promotion and injury and illness prevention programs on the grounds of economic efficiency. We do not pretend that these are the only grounds for implementing such programs; they simply represent one aspect of the problem.

To study the incentives of employers to invest in worker health, we use a standard profit function in which profits are equal to revenue minus costs. In this model, labor costs include wages paid as well as the costs of investing in worker health. An important feature of the model is that profits are strictly increasing in health. As with the case of individuals, we assume that employers make current period investments that only affect future health shocks. We also assume that employers must choose some fraction of current period profits to devote to future reductions in health shocks and some fraction to give to shareholders. With all of these assumptions we obtain a result for employer investment that is analogous to the case of individuals. Employers will invest in health until the expected increase in next period surplus equals the marginal cost of investment.

The distinguishing feature of our model is that it incorporates formally a direct incentive for both individuals and employers to invest in the health of individuals. Past studies have tended more to focus on employer investments in occupational safety only through the demand for it by workers.[6] What we have not yet discussed is how the model can be useful for thinking about the benefits of *coordinating* employer and individual efforts to promote health. By focusing on simply employer investments in safety through the workplace environment, we have adhered to the traditional focus on occupational safety. But suppose that employers also had the ability to influence individual health habits through a health promotion program, or that the government impose regulations affecting the healthiness of the workplace on the behalf of workers. Would there be gains to such policies?

It is a straightforward matter to show that the primary gains from a health promotion program in this setting are to reduce the cost of *information asymmetries* between individuals

[6] See, for example, Diamond (1977) or Rea (1981). Viscusi (1979) is, to our knowledge, the first to acknowledge that workplace injuries could lead to uncertain and reduced production for employers.

and employers about investments in health. Information asymmetries can arise because individual investments in alleviating health shocks affect the welfare of shareholders (through its impact on productivity, for instance), but in most cases the employer cannot verify the exact level of investment taken by workers. For example, it is difficult for employers to monitor the nutritional habits of individual workers. Alternatively, information asymmetries can arise if individuals underestimate the effect of employer investments in health. If either party is imperfectly informed about the investments in health by the other, this will prevent them from negotiating the level of investment in the contractual agreement.[7]

When either party maximizes their investment without considering the impact on the other's welfare, it will lead to sub-optimal levels of investment in health. The intuition for this result, derived formally in the appendix, is that the total social value comes from jointly maximizing both the welfare of shareholders and the welfare of workers. If workers only invest in health promotion without considering the welfare of shareholders, while firms only invest in injury reduction without considering the utility of workers, inadequate investment will result.

In many ways, the Occupational Safety and Health Act (OSHA) can be seen as addressing one half of this problem. Suppose workers do not perceive the benefits of employer health investments, they will not demand high levels of safety from employers. If employers are not given the incentives to sufficiently consider the benefits of their investments in workplace safety for their employees, then they will provide too little safety. Thus, by regulating a higher level of occupational safety, presumably the optimal level, then regulatory interventions such as OSHA can solve the problem of too little investment in safety by employers.

However, simply giving employer the incentives to invest more in workplace safety does not address the corresponding problem with worker health investments. Without further intervention, workers may not consider the potential gains to personal investment in health for employers, and hence will not invest the optimal amount in their own health. This is why health promotion programs are potentially important; employers may be able to use them to improve worker investments in health. Suppose we altered the model to give employers the ability to subsidize employee investments in health with a dollar transfer for every dollar invested by the

[7] The problem of unobservable health and safety measures has long been recognized to cause problems in contractual arrangements with regards to both nonoccupational and occupational health. Arrow (1968) discusses the problem of unobservable personal health habits for health insurance. Diamond (1977) focuses on the issue of unobservable safety precautions by workers. Rea (1981) discusses the problems that arise when workers misperceive the impact of employer investments in health.

worker. In such a scenario, employers would be willing to spend exactly up to the amount that generated the optimal level of personal investment in health.[8]

This discussion illustrates why employers may choose to adopt health promotion programs and why workers benefit from regulatory involvement in injury reduction (in both cases so that the gains to the other are considered when choosing their investment decision). However, it still leaves open the central question of this paper: whether or not there are gains to coordinating these interventions. In the model developed here, gains to coordination exist if there are *spillovers* between nonoccupational and occupational health investments in their effect on health.

Spillovers arise if nonoccupational heath investment makes investment in occupational health either more or less beneficial to employers (if, in the parlance of economics, the two are *compliments* or *substitutes*, respectively). Spillovers in health investments create gains to coordinating health promotion and injury prevention activities, because changes in the investment behavior of an individual will then lead to a different optimal level of investment by the employer. If these spillovers are not recognized, and individual and employer investment decisions are made independent of each other, we would not expect to obtain the optimal level of investment. This will be true even with well-designed interventions, if they are implemented separately.

There are a number of possible explanations as to why spillovers of this sort might exist. There may be physiological mechanisms that lead to a combined effect of occupational and nonoccupational risk factors that increase or lessen the impact of either on health. There could be psychological effects, whereby an effort to increase one's health in the workplace made them more committed to maintaining good habits at home. From an employer's perspective, there could be administrative effectiveness gains in terms of measuring outcomes or motivating participation. It is important to note, however, that the extent to which such spillovers exist could vary significantly among any of the important dimensions of the problem: namely, the specific types of health outcomes, risk factors and interventions.

[8] We note that the conclusion that there is underinvestment in health is by no means inconsistent with the observation that the United States pays too much for healthcare. The high amount spent on healthcare could indeed be a reflection of inappropriate investment in health promotion, as it may be more expensive to treat health conditions after they emerge than to invest in health activities and programs that prevent the problems from emerging. The investment in health that we are describing in this paper is of the activity and program flavor, rather than the treatment flavor.

4. Estimating Spillovers in the Impact of Occupational and Nonoccupational Risk Factors on Health Outcomes

The question of how cost effective injury prevention and health promotion programs are, either separately or jointly, remains largely unanswered. Actually determining cost effectiveness would take a large research effort that carefully selected measurable outcomes and inputs, as well as cost variables, and some form of randomization. This would likely require either a group of participating employers or at least one very large employer with many establishments over which to randomize. Additionally, given the length of time over which it may take some health conditions to develop, it would require a long time-path for the study to fully capture the benefits to employers and workers. Even with all of these elements, there are substantial challenges in measuring the true cost of any given health affliction to an individual.[9]

A large-scale examination of the costs and benefits of an integrated injury prevention and health promotion program is beyond the scope of this paper. Instead, we study how personal and job-related health risks affect health shocks, both individually and jointly. While our analysis will be largely descriptive, given that we will not be able to distinguish whether the effects we measure are causal or selective in nature, we believe it will highlight some of the important issues that need to be considered when studying the role of modifiable job and personal risk factors on health.

4.1 Data and Methods

We use data on health status, personal health habits and job-related risks from the Health and Retirement Study (HRS). The HRS is a nationally representative panel sponsored by the National Institute of Aging and conducted by the Institute for Social Research at the University of Michigan. The Study targeted individuals (and their spouses) aged 51-61 at the time of the first wave (1992), and was intended to provide information on health and retirement issues for the older community-dwelling population. Follow-up surveys were conducted biennially after 1992. The survey over-sampled Blacks and Hispanics, and includes weights that can be used to make it nationally representative for the 48 contiguous states.

[9] One of the key problems is how to measure the noneconomic harm to an individual in dollar terms. Viscusi and Evans (1990) attempt to estimate these effects using survey data, but there remain challenges to measuring such effects in practice.

As discussed above, there are numerous potential individual and work-related variables that could impact health. To focus our analysis, we consider a single personal health habit, smoking behavior, and a single job-related factor, the exposure to potentially harmful materials at work. These are useful for our purposes because both are clearly distinct in terms of their work relatedness, and both are well known to be associated with poor health. In addition, it is generally recognized that there may be spillovers in the two in terms of their impact on health; it has been argued that the health risks from exposure to asbestos are far more likely to manifest in smokers than in nonsmokers (US Department of Health, Education and Welfare, 1979; US Department of Health and Human Services, 2001).

The smoking variable that we utilize asks if an individual ever smoked cigarettes. This was asked in the initial wave, and follow on questions were asked regarding current (at the time of the survey) smoking behavior. The exposure question was also asked in wave 1, and read as follows

> Individuals are sometimes exposed to dangerous chemicals or other hazards at work. Have you ever had to breathe any kinds of dusts, fumes, or vapors, or been exposed to organic solvents or pesticides at work?

If the individual responded affirmatively to this question, follow up questions were asked regarding the nature and duration of the exposure.

We consider the impact of smoking and exposure to toxic chemicals on four potential health outcomes: respiratory disease (chronic lung disease, except asthma, such as chronic bronchitis or emphysema), cancer or a malignant tumor of any kind except skin cancer, heart disease (heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems), or arthritis (including rheumatism). We expect that both smoking and exposure to harmful substances could have an impact on the first three of these, particularly respiratory disease. Arthritis, on the other hand, is included as a robustness check. We expect that the risk of suffering arthritis because of either smoking or exposure to harmful chemicals should be small, given that neither is commonly recognized as a risk factor for arthritis. Therefore, any effect of smoking or exposure on arthritis that we observe should be due at least in part to correlation between these variables and unobserved variables indicating poor health status. While this will not allow us to obtain causal estimates for the impact of smoking and exposure on health shocks, it will provide some insight as to whether or not selection appears to be prominent in our analysis.[10]

4.2 Results

Table 1 provides some summary statistics for the key variables used in our analysis. The summary statistics represent the characteristics of individuals in Wave 1 of the HRS. Most important for our analysis is to note that about 64 percent of individuals in our sample report ever smoking, while about 39 percent report ever being exposed to hazardous materials at work (about 27 percent report both). Almost 33 percent of individuals report being exposed to hazardous materials for more than one year.

In Table 2 we illustrate the nature of the hazardous materials to which individuals report being exposed. The most common material was some form of chemical solvent, with the second most common being minerals and fumes other than asbestos (asbestos was the fifth-most common type of exposures). Note that individuals were allowed to report two forms of exposure, so we report the distribution of both exposure types in Table 2. For individuals that were exposed to hazardous materials, a separate question in the HRS indicates that approximately one-quarter felt that it had some adverse impact on their health.

In Figure 1 we examine the effect of exposure to hazardous materials on the prevalence of lung disease. For the figure, we use the response to the hazardous exposure question in Wave 1 and then examine the frequency of lung disease in all waves by current age (so we count individuals multiple times over different waves). The figure indicates a clear effect of reported exposure to hazardous materials on the reported prevalence of lung disease. The difference appears to be about a 4-5 percentage point increase in the frequency of lung disease for the exposed across all ages, with only a slightly higher gradient for the exposed category.

Figure 2 breaks down the data into four groups based on whether or not the individuals report ever smoking or ever being exposed to harmful materials. This allows us to examine the direct effect of our measures of individual and employer health risks, as well as the combined effect of the two. From the figure, we see that the combined effect is significant, indicating a propensity for lung disease of close to 10% in the early 50's and rising to nearly 20% at age 70.

[10] All regression analyses account for the complex sampling design of the HRS using information on the survey weights, strata and primary sampling units as implemented in survey data estimation commands in Stata 7.0 (Stata Corporation, College Station, TX). The Huber/White nonparameteric correction is used to adjust standard errors for repeated observations on the same individuals.

Both smoking and exposure appear to have an individual effect on lung disease, with the direct effect of smoking apparently larger.

Clearly, the danger of exposure to hazardous materials at work in terms of lung cancer appears worse for individuals who smoke. We now examine this relationship controlling for additional covariates (race, gender, education and industry type), and examine the relationship for other health conditions. We do this with a series of estimated probit models, the results of which are reported in Table 3. The dependent variable in the probit models is whether an individual reported one of the four health conditions mentioned above (lung disease, cancer, heart disease or arthritis), either in the first wave or a later wave. We report results separately for any exposure to harmful chemicals, and for exposure that lasted longer than one year. We also report results with and without interaction terms between smoking and exposure.

With reference to our earlier model, the variables for smoking and exposure represent the individual and private investment in reducing health shocks, respectively. We cannot say for sure what the impact of this investment on individual and employer value functions is, because we cannot translate from the health shock to the welfare of either party. Clearly these conditions will be negative for individuals, but it is less clear whether or not they will be so for employers (particularly for individuals at old age). The interaction term can be seen as a test for spillovers between the individual and employer investments.

Column I of Table 3 shows that both smoking and exposure are correlated with significantly increased risk for all conditions. Looking at Column III, we see that exposure for more than a year is associated with a larger risk for the three primary health risks, which we would expect, but the effect is not large. For all conditions except arthritis, the direct effect of smoking is larger than that of exposure. Table 3 also indicates that smoking and exposure are complements with regards to their impact on lung disease, though the interaction term is not statistically significant for heart disease or cancer. Note that the effects of any exposure and exposure for more than a year are nearly identical, likely reflecting the fact that most who were exposed were exposed for at least a year.

It is generally difficult to directly interpret probit coefficients in an intuitive manner, so in Figure 3 we report the predicted probabilities from the model by smoking and exposure (taking the other variables at their mean values). The figure suggests that there is a direct effect of both smoking and exposure, though the direct effect of exposure is small for lung disease (and not statistically significant in Table 3). The direct effects are larger for cancer and heart disease, though the interaction terms do not appear as large. In general, smoking and exposure appear to be complements with regards to their impact on these diseases, though the effect is only strong for lung disease.

In Figure 4 we extend the analysis to display the predicted results for arthritis. Note that arthritis is far more common than the other three conditions, with our model predicting nearly 60 percent frequency for all four groups. In general, we see that there appears to be very little direct effect of smoking or exposure on the prevalence of arthritis, but there is a joint effect. Workers who smoked and report being exposed to hazardous materials appear roughly 8-10 percentage points more likely to suffer from arthritis. The most likely explanation for this would appear to be selection; smokers who are exposed to toxic chemicals could have more physically demanding jobs or worse baseline health characteristics that make them more susceptible to arthritis.

The results for arthritis clearly suggest that one explanation for the strong impact of both smoking and exposure to hazardous materials on the other health conditions could be selective rather than causal. The causal interpretation is that exposure to hazardous materials at work and smoking combine to worsen health outcomes for individuals. The selective interpretation would suggest that individuals who are more vulnerable to poor health, perhaps because of heavier smoking or some other unobserved characteristic, are also more likely to be exposed to hazardous materials at work. This result raises important public policy concerns regardless of which interpretation is the correct one. However, the selection explanation does not as readily suggest that integrating health promotion and injury reduction programs will have multiplicative health benefits.

Overall, our analysis reinforces that there are large potential gains to individual health from modifying individual and employer risk variables. Furthermore, there is at least some evidence that the health outcomes for individuals could be made better off by jointly reducing smoking and exposure to harmful chemicals at work. We only consider two types of behaviors and a handful of health conditions, but there are many possible combinations that one could consider. Future work should expand the analysis to determining the effect of different behaviors on different kinds of individual health, but clearly must be careful to control for the possible selection on unobserved characteristics.

5. Conclusions

As long as we maintain a system in which the health and health care of individual workers are tied so closely to the employer, we will in all likelihood continue to see a strong interest in health promotion programs. And as long as the distinction between occupational and nonoccupational injuries continues to fade, it is likely that there will also be continued interest in coordinating health promotion and injury and illness prevention programs. However, there remain substantial gaps in our knowledge about just how cost-effective such programs are, taken in isolation or considered jointly.

This paper discusses some economic issues that need to be considered when studying health promotion and injury and illness prevention programs. We outline a model for discussion of how individuals and employers could benefit from investing in individual health. Our primary finding is that the gains, in terms of economic efficiency, to coordinating health promotion and injury prevention programs arise if there are spillovers between the effects of occupational and nonoccupational risk factors on health. If positive spillovers are present, then recognition of the interaction between the two programs will be necessary in order to correctly evaluate the cost effectiveness of either programs, and there are likely to be health benefits from their coordination.

We also discuss some empirical issues related to estimating the gains to these programs, and illustrate these with an analysis of how smoking and exposure to toxic chemicals combine to affect the health of individuals. Our results suggest that workplace conditions and health habits both influence individual health, and that the effect appears more than additive for some health conditions (suggesting a positive spillover). However, the analysis is also suggestive of the possibility that sample selection could be contributing to the estimates of spillovers.

Clearly, much work remains to be done on this issue. The outcomes we focus on in this paper are restricted primarily to those directly related to the health of workers, but there are other potential gains to coordinating health promotion and injury prevention programs that we do not consider. For instance, the administrative savings from a coordinated program could potentially be large, particularly for larger firms that self-insure both occupational and nonoccupational health care costs.

However, even focusing on just the direct impact of interventions on health outcomes, it is no simple matter to determine cost-effectiveness. Given the various ways in which the costs of health and health risks may be transferred between individuals and employers through wage negotiations, it could be very difficult to obtain a complete accounting of the difference between employer costs with and without an integrated program. Also, given that our empirical results suggest that some of the impact of workplace safety investments may occur in older individuals (our sample of individuals were all age 50 or over), there are reasons to believe that the full benefits of prevention measures will not be recovered by employers (as most health care costs for older individuals will likely be borne by Medicare). All of this suggests a need for a great deal of additional research aimed at determining the optimal intervention in health promotion and injury prevention programs.

Technical Appendix

In this appendix, we present a formal model of investment in individual health by employers and workers. We then show how maximizing investment for each agent without considering the impact on the other agent's welfare will lead to sub-optimal levels of investment in health. If we think of integrated health promotion and injury and illness prevention programs as facilitating the joint maximization of investment, then such integration will be welfare enhancing for both parties. Here we focus primarily on the technical aspects of the model, and leave the intuition for the results to the text.

A1. Model Setup

In this section we set up a model where both workers and employers have the ability to reduce the likelihood of adverse shocks to future health, though not eliminate them entirely. As we proceed, we also derive the equilibrium conditions for worker and employer investment levels *assuming that neither considers the possible impact of one's own investment on the others welfare*.

We formulate the relationship between health in one time period to that in the previous time period with Equation 2

(2) $$H_{t+1} = (1 \square \partial) H_t \square \square_t ,$$

where H_t represents the stock of available health in time t, $\square$ is the rate of depreciation on health, and $\square$ is a random health shock.[11] This equation simply states that as an individual, your health in the future is equal to your health in the past minus any natural depreciation (through the aging process) and any adverse health shocks. We assume that the shock is a random variable distributed according to the distribution function $F(\square \mid \square, \square)$, where $\square$ represents individual health habits (controlled by the worker) and $\square$ represents the quality of the work environment in terms of health (controlled by the employer). The likelihood of a health shock is decreasing in both individual health habits and workplace health investments at a decreasing rate.[12]

[11] The health shock could be introduced in any number of ways, such as a jump in the level of depreciation, but we make it additive for simplicity.

[12] Thinking in terms of the *expected* health shock, denoted $E(\square \mid \square, \square)$, then we have $\frac{\partial E(\square \mid \square, \square)}{\partial \square} < 0$, $\frac{\partial E(\square \mid \square, \square)}{\partial \square} < 0$, $\frac{\partial^2 E(\square \mid \square, \square)}{\partial \square^2} < 0$ and $\frac{\partial^2 E(\square \mid \square, \square)}{\partial \square^2} < 0$.

Individual utility is increasing concave in both consumption of goods and health subject to a budget constraint. Suppose that individual investment in reducing health shocks is costly, with a unit cost of $m_{\square}$. Let individual utility in time t be given by the function

(3) $$U_t(z_t, H_t),$$

where z are goods consumed by the individual. Consumption is subject to the budget constraint

(4) $$z_t + m_{\square}\square_t \;\square\; w(H_t),$$

where $w(H)$ represents the individual's wages.[13]

Consider the value function $v(H_t) = U_t(c_t, H_t) + \square v(H_{t+1})$, where $\square$ is the next period discount rate. In our model, health is known in time t, but individual current period investments in health only affect health shocks in the next period. Thus, in time t individuals choose c_t and $\square_t$ to maximize $U_t(c_t, H_t) + \square \mathrm{E}(v(H_{t+1}))$ subject to the resource constraint given by Equation 4. Carrying out this maximization yields the first order conditions $U_c = \square$ for c_t and

$$\frac{\square}{\square}\left(\frac{\partial E(v(H_{t+1}) \mid \square_t, \square_t)}{\partial \square_t}\right) = m_{\square}$$ for $\square_t$, where $\square$ is the Lagrange multiplier for the optimization

problem. As long as $W_H > 0$, next period health and utility unambiguously increase in current period investments.[14] Given this, economic theory holds that individuals will invest in $\square$ until the discounted value of the marginal increase in expected, next-period utility equals $m_{\square}$.

Now consider employers. Let employer profits be given by

(5) $$Y(H_t) \;\square\; \{w(H_t) + c(H_t)\},$$

where $Y(H)$ is per-worker output and $c(H)$ represent the per-worker costs of poor worker health that are borne by the employer.[15] We assume that the marginal product of workers is increasing concave in their health, so $Y_H > 0$ and $Y_{HH} < 0$. The cost function c is decreasing concave in health, so $c_H < 0$ and $c_{HH} > 0$.[16] As long as wages do not increase too quickly with H, employer profits at time t are increasing in the health of workers at time t.

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[13] Throughout this paper we assume that there is no borrowing, by individuals or by employers.

[14] We expect that wages increase in health either because healthier workers have a higher marginal productivity or simply because they are able to work more. In practice, there are programs (such as workers' compensation and disability compensation programs) that reduce the economic impact of a disability. Nevertheless, these compensation mechanisms typically replace much less than 100% of lost wages.

[15] In principle, employers should care about maximizing aggregate profits. For our analysis, we must assume identical workers and a production function that is linear homogeneous of degree one, allowing us to divide through by total employment and focus on the individual worker level.

[16] Strictly speaking, we do not need the cost function for our analysis, so our results would be the same if $c(H) = 0$ for all H.

As with individuals, we assume employers make current period investments that only affect future health shocks. Employers choose some fraction of current period profits to devote to future reductions in health shocks and some fraction to give to shareholders. Letting s_t denote the value of profits given to shareholders in time t, we can define the resource constraint for per-worker investment in health as

(6) $$s_t + m_{\square}\square_t \ \square\ Y(H_t) \ \square\ \{w(H_t) + c(H_t)\}.$$

Since we ignore savings, profits are fully distributed between investment and payments to shareholders.

Suppose that employers operate to maximize shareholder value, and the value function of shareholders is $X(H_t) = D(s_t) + \square X(H_{t+1})$, where D represents the direct gain to shareholders from consuming current period surplus. As with the individual value functions, future surplus is uncertain because of health shocks. Taking expectations and maximizing shareholder value with respect to s_t and $\square$ constrained by Equation 6 yields the first-order conditions $D_s = \square$ for s_t and $\frac{\square}{\square}\square\frac{\partial E(X(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t}\square = m_{\square}$ for $\square$, where $\square$ is the Lagrange multiplier. Analogous to the case of individuals, employers invest in health until the discounted value of the marginal increase in expected next period surplus equals the marginal cost of investment.

A2. Information Asymmetries and Spillovers

Here we examine the model under the assumption that information asymmetries prevent workers and employers from negotiating the optimal level of investment. We assume a complete failure, though analogous results are obtained if there is only a one-sided asymmetry (for example, if worker investments are unobservable but employer investments are not). Essentially, the failure of employers and workers to consider the effect of one’s own investment on the other’s welfare leads to externalities, and therefore the equilibrium levels of investment described above are sub-optimal. We then show that if there are spillovers, if worker and employer investments are strategic substitutes or compliments, then interventions designed to promote investment will only be optimal if they choose the level of promotion jointly. This result lays the foundation for the economic argument in favor of integrating health promotion and injury and illness prevention programs.

Consider the value functions from before, $v(H_t)$ and $X(H_t)$. In the model discussed above, individuals and employers maximize only their respective value function irrespective of the other. A social planner who, for simplicity, places equal weight on both workers and employers would maximize the sum $v(H_t) + X(H_t)$ with respect to c_t, s_t, $\square_t$, and $\square$ while taking Equations 4 and 6 as constraints. It is straightforward to show that the first order condition for $\square_t$ in this maximization is $\frac{\square}{\square_1}\left(\frac{\partial E(v(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t} + \frac{\partial E(X(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t}\right) = m_{\square}$ and the first-order condition for $\square$ is $\frac{\square}{\square_2}\left(\frac{\partial E(v(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t} + \frac{\partial E(X(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t}\right) = m_{\square}$, where $\square_1$ and $\square_2$ are the Lagrange multipliers for Equations 4 and 6, respectively. These equations clearly differ from the previous first-order conditions, due to the introduction of terms representing the externality that one agent's investment has on the other's welfare. Because both left-hand side terms in both first-order conditions are decreasing in $\square$ and $\square$ respectively, the socially optimal equilibrium will involve higher levels of investment in safety than the privately optimal equilibrium.

It is important to emphasize that externalities such as these would normally only occur outside the context of a contractual relationship. The so-called Coase Theorem tells us that externalities are only problematic if there are transaction costs of some sort that prevent the parties from negotiating a solution (Coase, 1960). However, information asymmetries create a market failure that can prevent these private negotiations from generating the efficient solution (because when investment is unobservable, incentives exist to report a higher level of investment than is actually taken).

Note that the social planner maximizes social welfare with respect to $\square_t$, and $\square$ jointly. This means that any spillovers between the two will be incorporated into the estimation. In this context, spillovers arise when there is strategic complimentarity or substitutability between the two types of investment. Consider the value functions $E(v(H_{t+1})|\square_t,\square)$ and $E(X(H_{t+1})|\square_t,\square)$. The investment variables $\square$ and $\square$ are considered strategic complements if $\frac{\partial^2 E(v(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t \partial \square_t} > 0$ and $\frac{\partial^2 E(X(H_{t+1})\,|\,\square_t,\square_t)}{\partial \square_t \partial \square_t} > 0$, and strategic substitutes if the inequalities are reversed. If health promotion and injury prevention programs are designed separately it is possible that they will be "myopic," in the sense that they will fail to consider these spillover effects.

Suppose that a government felt that $\square$ and $\square$ were below their optimal levels, and decided to implement separate programs to raise them. The natural solution for a myopic program is to design the intervention to raise each to the point that the private marginal benefit of investment with respect to [illegible] and [illegible] equaled their respective marginal cost. However, suppose that [illegible] and [illegible] are complements. If this is true, and the policies were implemented separately and without any coordination, then the programs would be designed to implement the optimal level of [illegible] assuming that [illegible] is fixed at it's old level, and vice versa. But because of the complimentarity of the two, this will result in a marginal value of investment that is greater than the marginal cost, so there will be too little investment in worker health. The opposite result will hold if the two are substitutes.

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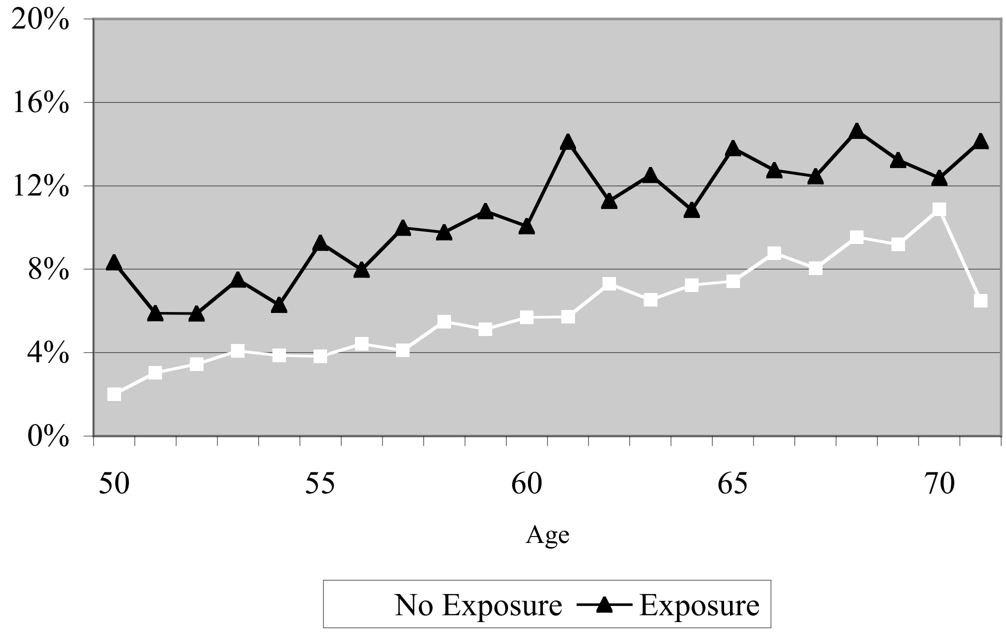
Figure 1. Frequency of Lung Disease by Age and Exposure Status



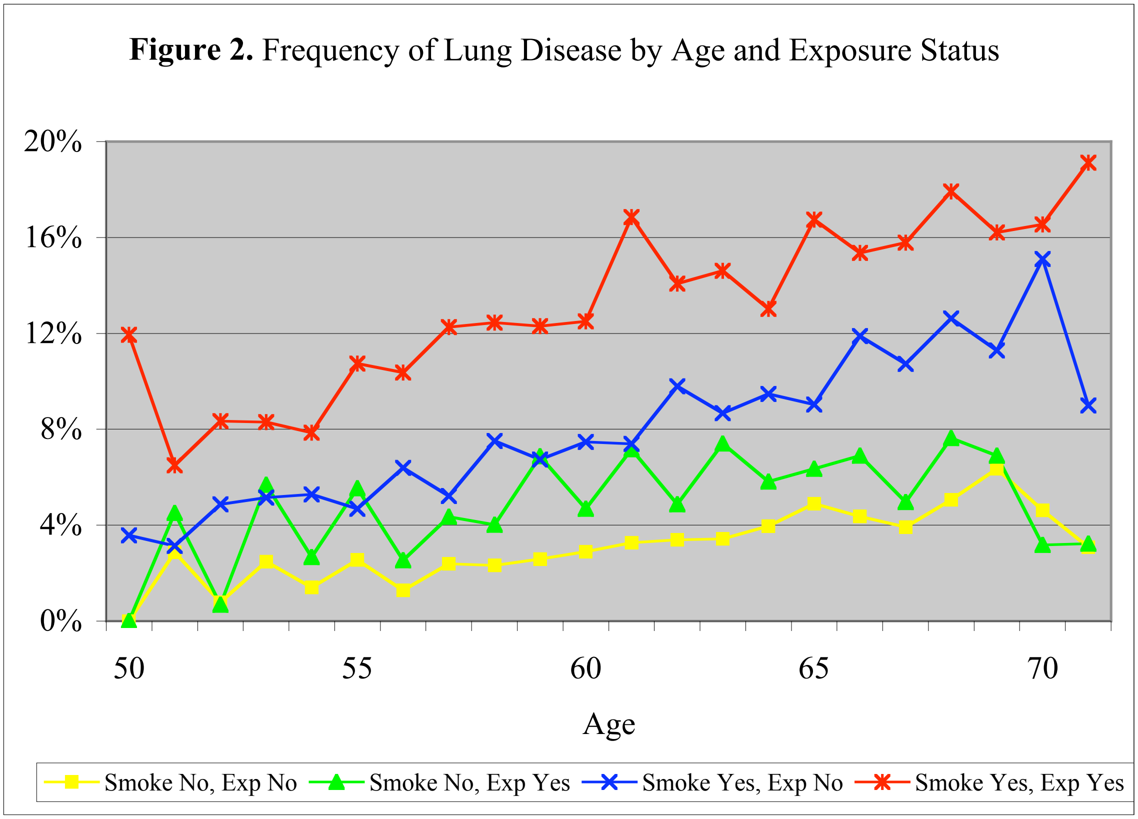


Figure 2. Frequency of Lung Disease by Age and Exposure Status
20%
16%
12%
8%
4%
0%
50
55
60
65
70
Age
Smoke No, Exp No
Smoke No, Exp Yes
Smoke Yes, Exp No
Smoke Yes, Exp Yes

Figure 3. Predicted Probability of Ever Suffering a Condition by Smoking and Exposure to Hazardous Materials

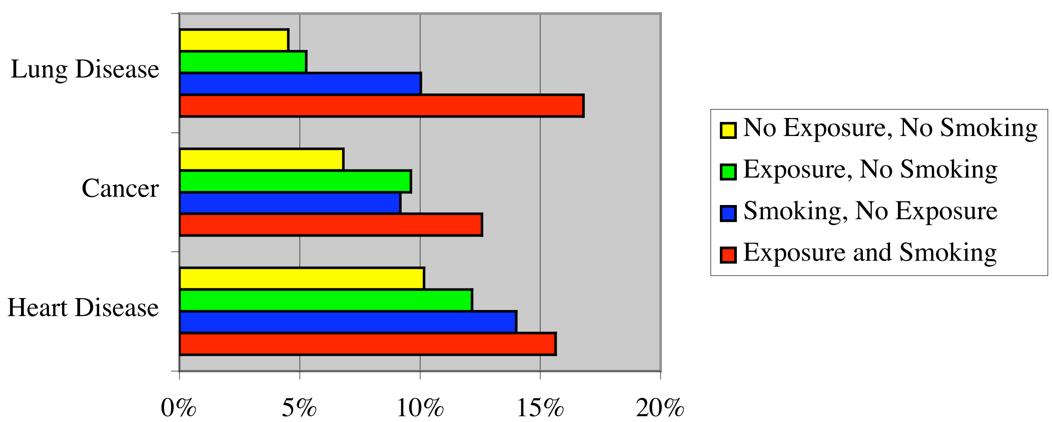


Figure 4. Predicted Probability of Ever Suffering a Condition by Smoking and Exposure to Hazardous Materials

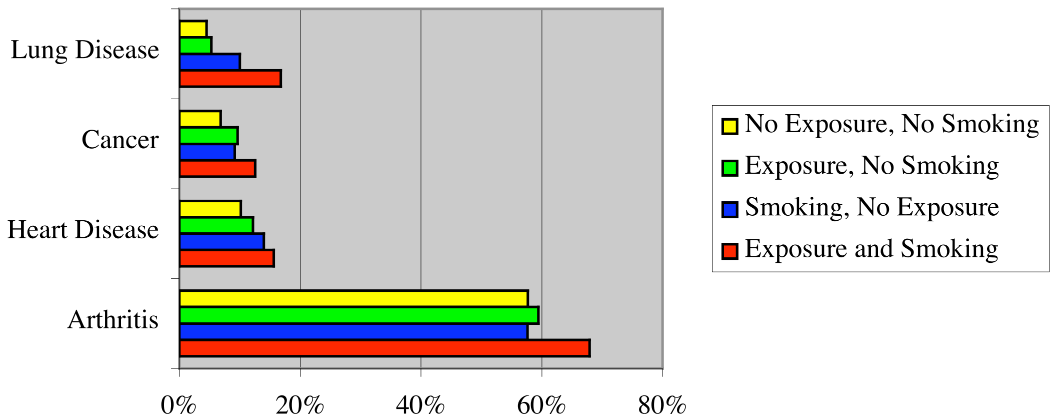


Table 1
Summary Statistics

Variable	Mean	95% Confidence Interval
Age	55.6	[55.49, 55.63]
White	86.2%	[85.56, 86.75]
Female	52.4%	[51.30, 53.44]
Ever Smoked	63.90%	[62.91, 64.96]
Ever Exposed to Hazardous Substances	39.20%	[38.12, 40.30]
Smoked * Exposed	27.70%	[26.68, 28.68]
Exposure of Greater than 1 Year	32.70%	[31.68, 33.78]
Smoked * Long Exposure	23.20%	[22.25, 24.13]
Number of Observations: 9,771		

Notes: Number of observations represents the number of observations in Wave 1 of the HRS. The total number of observations in all waves in our data is 49,539. Note that some variables might have missing values, most notably the exposure to hazardous substances variable. Means and confidence intervals are calculated using weights reflecting the complex survey design of the HRS.

Table 2.

Types of Hazardous Materials Respondents Workers Report Being Exposed To

	First Category		Second Category	
	Number	Percent	Number	Percent
Solvents	832	29.4	477	33.73
Petroleum Products	202	7.1	121	8.56
Asbestos	293	10.3	68	4.8
Other Fumes and Dust	506	17.9	211	14.9
Biohazards (Inc. Wood and Paper)	191	6.7	65	4.6
Inorganic Materials (Inc. Acid)	199	7.0	143	10.1
Agricultural	296	10.4	124	8.8
Drugs and Explosives	20	0.7	9	0.6
Other	295	10.4	196	13.9
Total	2,834	100	1,414	100

Notes: There are 531 workers that do not report the type of exposure they faced. Workers are given the opportunity to list two types of materials to which they were exposed, and if they do this is reported above as the second exposure category.

Table 3
Impact of Smoking and Exposure to Harmful Substances on Health Shocks to Individuals

	Any Exposure		Exposure > 1 Year	
	I.	II.	III.	IV.
Lung Disease				
Exposed	0.2617	0.0736	0.2988	0.1397
	(6.28)**	(0.85)	(6.99)**	(1.57)
Ever Smoked	0.5087	0.4127	0.5100	0.4396
	(10.44)**	(6.62)**	(10.45)**	(7.32)**
Exposure*Smoked		0.2438		0.2049
		(2.49)*		(2.05)*
Cancer				
Exposed	0.1840	0.1868	0.1853	0.1493
	(4.46)**	(2.64)**	(4.38)**	(2.00)*
Ever Smoked	0.1590	0.1605	0.1590	0.1428
	(3.86)**	(3.09)**	(3.86)**	(2.89)**
Exposure*Smoked		-0.0040		0.0513
		(0.05)		(0.58)
Heart Disease				
Exposed	0.0811	0.1048	0.1213	0.1019
	(2.28)*	(1.68)+	(3.33)**	(1.58)
Ever Smoked	0.1784	0.1912	0.1776	0.1688
	(4.92)**	(4.16)**	(4.89)**	(3.85)**
Exposure*Smoked		-0.0338		0.0274
		(0.46)		(0.36)
Arthritis				
Exposed	0.1971	0.0452	0.1489	0.0343
	(5.93)**	(0.81)	(4.33)**	(0.59)
Ever Smoked	0.0803	-0.0009	0.0814	0.0312
	(2.47)*	(0.02)	(2.50)*	(0.81)
Exposure*Smoked		0.2272		0.1693
		(3.42)**		(2.43)*

Notes: Each column and panel reports the estimated coefficients from a probit model taking into account the sampling in the HRS. t-statistics are reported in parentheses. A ** represents statistical significance at the 1% level, a * represents significance at the 5% level and a + represents significance at the 10% level. All regressions include dummy variables for the respondents' age, education, race, gender and the industry for which they worked the longest.